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Taxonomy and geographic distribution of a northwestern Venezuelan toad (Anura, Bufonidae, *Bufo sternosignatus*)

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In this paper we provide a redescription of *Bufo sternosignatus*, a northwestern Venezuelan toad usually associated with the "*Bufo typhonius* complex", and detailed data on its external morphology, skin, meristic characters, pattern of coloration in life and after preservation, and biogeography.

INTRODUCTION

Bufo sternosignatus was described by Albert GÜNTHER (1859) in a book dealing with the anurans deposited in the collection of the British Museum of Natural History (London). The type series included a male and a female from "Venezuela", a female from "Puerto Cabello" (Estado Carabobo, Venezuela), and two Mexican juvenile toads stated as coming from "Mexico" and "Cordova". The latter were considered by BOULENGER (1882: 320) as *Bufo valliceps* Wiegmann, 1833, a decision followed by KELLOGG (1932: 68). The treatment of *Bufo sternosignatus* as a junior synonym of *Bufo valliceps* by PORTER (1964: 242) probably reflects this partial assignment, inasmuch as BOULENGER (1882) restricted the name to the Venezuelan types, although PORTER (1964) did not do this. BOULENGER (1882: 323) also assigned to *B. sternosignatus* two specimens coming from

Source : MNHN, Paris

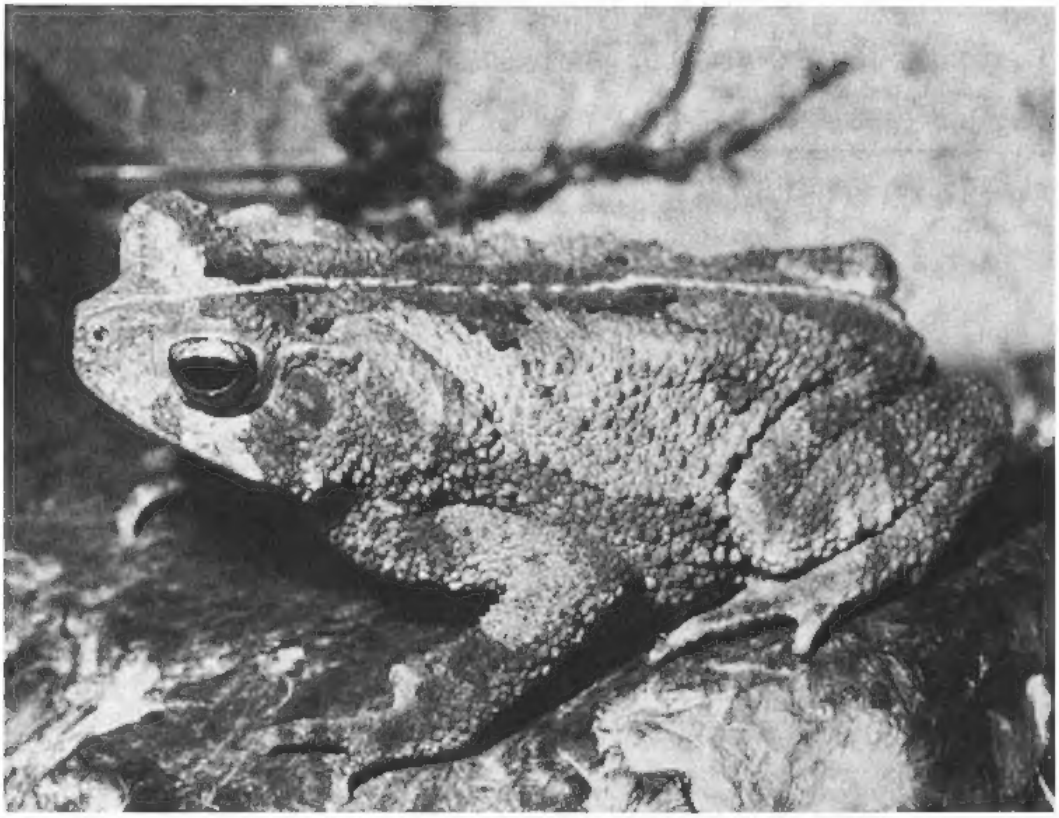

Fig. 1. — *Bufo sternosignatus*, ULABG 1924, adult female, SVL 48.6 mm.

"Bogotá" (Colombia). Two other records from Colombia, Cafetal Amelia, near Angelópolis, 1820 m, by PERACCA (1914), and Cañón de Tolima, by WERNER (1916), were denied by RIVERO (1961: 29), who considered them as probably referring to *Bufo typhonius alatus*. COCHRAN & GOIN (1970: 112) retained the Bogotá frog in the Colombian fauna, "on the strength of BOULENGER's identification".

The specific status of *Bufo sternosignatus* was apparently not questioned until SHREVE (1947) treated it as a subspecies of *Bufo typhonius*, with the provision that "even though *Bufo typhonius alatus* Thominot, 1884 from Panama should prove to be synonymous, *sternosignatus*, being the older name, will have to be used". RIVERO (1961: 28-29) considered the species to be very similar to *Bufo typhonius alatus*, adding that it "perhaps interbreeds (though not freely) in part or all of its range", and later (RIVERO, 1964*b*: 314) that they "seemed to be most closely related". All other references to the species in the literature have appeared in catalogues or locality lists under *Bufo sternosignatus* (e.g. LUTZ, 1927*a-b*, 1955; PARKER, 1935; SHREVE, 1947; SMITH & TAYLOR, 1950; GINÉS, 1959; RIVERO, 1964*a-b*, 1967; SOLANO, 1969; MÜLLER, 1973; LYNCH, 1979; HARDING, 1983; FROST, 1985; LA MARCA, 1992*a*, 1995).

Bufo sternosignatus was placed in the *Bufo typhonius* group by CEI (1972) and as such it is still recognized. The most recent grouping of South American bufonids (by DUELLMAN

Source : MNHN, Paris

& Schülte, 1992) placed the species in the *typhonius* group along with the following species: *B. ceratophrys* Boulenger, 1882; *B. dapsilis* Myers & Carvalho, 1945; *B. iserni* (Jiménez de La Espada, 1875); *B. nasicus* Werner, 1903; *B. roqueanus* Melin, 1941; and *B. typhonius* (Linnaeus, 1758). Hoogmoed (1989) was of the opinion that even those species do not form a natural group and recommended that the name *Bufo typhonius* be suppressed, because of nomenclatural problems and the confusion surrounding this name. Regarding *B. sternosignatus*, Cei (1972) had otherwise indicated that "it might alternatively be related to *B. granulosus*". The systematic status of *B. sternosignatus* remains problematic, as was pointed out by Hoogmoed (1990), who also indicated that "statements about relationship seem to have been made on the basis of general appearance (colour and pattern) and not on any hard morphological data". After examining the Venezuelan syntypes, Hoogmoed (1990) concluded that these certainly were not *Bufo valliceps*, that they were not related to *Bufo granulosus* either, and did not rule out the possibility that the species is identical to *B.* "*typhonius*" from Panama and adjacent North America.

Although relatively easy to set apart from other Venezuelan bufonids, *Bufo sternosignatus* (fig. 1) has not been properly studied, probably due to the paucity of specimens in collections. We had the opportunity to collect the species in the field, and from the examination of these and other museum specimens we conclude that, although it shares the pale vertebral line and a so-called "dead-leaf pattern" with some species in the "*typhonius* group", it is a perfectly valid and distinct taxon probably not related to any species in this complex. We do not rule out the possibility that it might be related to *Bufo granulosus*. *Bufo sternosignatus* is readily distinguished from other northern South American bufonids by being more spinose, by having very distinct tympana, oval-shaped spinose parotoid glands, a pale cross design on ventral surfaces, and by the tubercles on flanks disposed in lateral rows running somewhat parallel to the dorsum. Although the type locality of *Bufo sternosignatus* was restricted by Cochran & Goin (1970: 111) to "Puerto Cabello, Venezuela", which "almost" amounts to a lectotype designation, no proper such designation has ever been published for this species. Unfortunately, we could not study the syntypes, nor could we designate a lectotype, an action we feel needs to be done in the frame of a revisionary work on the systematic relationships of the species, a task beyond the scope of this paper. Nonetheless, we offer here a redescription and additional data on the species, in the hope that they may help for such a revisionary work.

Material and methods

Museum abbreviations employed in the text are as follows: CIEZAH, Colección Herpetológica del Centro de Investigaciones en Ecología y Zonas Aridas, Universidad Francisco de Miranda, Venezuela; CVULA, Colección de Vertebrados, Universidad de Los Andes, Venezuela; MCNG, Museo de Ciencias Naturales Guanare, Venezuela; ULABG, Colección de Anfibios y Reptiles, Instituto de Geografía, Universidad de Los Andes, Venezuela; UMMZ, University of Michigan Museum of Zoology, USA.

The following specimens of *Bufo sternosignatus*, all new records from Venezuela, and upon which is based the redescription of the species, were examined during the course of this study:

Source : MNHN, Paris

Estado Aragua: ULABG 3947, La Trilla, near Ocumare de La Costa, 150 m. Estado Barinas: CVULA 5158, Barinitas. Estado Carabobo: ULABG 1319, Hacienda Bucarito, near Montalbán, 700 m. Estado Falcón: CIEZAH 322, road to Cerro Galicia, near Curimagua, 1150 m; MCNG 2190-2191, Finca La Felipina, approx. 3 km from La Soledad de Uria, Sierra de San Luis, ca. 1300 m; CIEZAH 323, CVULA 5118-5119, Cataratas de El Hueque, Parque Nacional J. C. Falcón, Sierra de San Luis, 800 m; CIEZAH 317-319, San Diego, Sierra de San Luis, approx. 1100 m; ULABG 2940, Cerro Chichiriviche. Estado Portuguesa: ULABG 3726-3727, 6 km from Río Saguaz, on road Biscucuy-Chabasquén, 585 m. Estado Trujillo: ULABG 1924, carretera Boconó-Trujillo, near intersection with road Trujillo-La Concepción; ULABG 2667, Agua Negra near Sabaneta, 1405 m, on road from Trujillo to San Lázaro.

Terminology, measurements and web formula system follow La Marca (1984, 1989, 1994*b*).

Redescription of *Bufo sternosignatus* Günther, 1859

Diagnosis and definition

A moderate-sized species of *Bufo* (mean SVL: 5 males, 49.5 mm; 5 females, 42.3 mm) having the following combination of characters: (1) distinct supraorbital and anteorbital crests bordering upper eyelid and anterior part of eye; (2) supratympanic crest prominent; (3) parotoid glands oval-shaped and densely tuberculate; (4) snout truncated in dorsal view; (5) tympanum large (about 2/3 the horizontal length of eye); (6) skin densely tubercular with numerous minute spicules; (7) a pale-cream cross usually present on chest.

Bufo sternosignatus occurs sympatrically with *B. marinus*, but may be distinguished by the following characters (in *B. sternosignatus*): smaller size, shorter head, smaller tympanum, stronger supratympanic crest, snout truncated in dorsal view, and body surfaces bearing minute spicules. *B. sternosignatus* more closely resembles *B. typhonius alatus*, but differs by having a non-prominent snout, less prominent supraorbital crest, weak occipital crest, parotoid glands oval-shaped, hands and feet with minute spicules, metatarsal fold absent, and a pale-cream cross usually present on chest. *B. sternosignatus* could also be confused with *B. granulosus*, but differs from the latter by having a larger size, longer head, stronger supratympanic crest, smaller spicules on hand and feet, more truncated snout, crests around nostrils absent, and no well-defined crest along canthus rostralis.

Description

Head twice as long as wide and twice as wide as deep, narrower than body width; top of head flat to slightly concave in the middle, shifting to slightly convex in the postoccipital region, with prominent warts (ca. 0.5 mm in diameter), some of them coalescing to form canthus rostralis. Canthus rostralis curved, well defined. Distinct supraorbital and anteorbital crests bordering upper eyelid and anterior part of eye. Loreal region slightly

Source : MNHN, Paris

concave, descending almost vertically to upper lip; snout truncated in dorsal view, slightly protruding (sensu HEYER et al., 1990: fig. 80) in lateral view; nares oval to rounded, directed dorsolaterally; nostrils elevated, closer to tip of snout than to eye (about 1/5 of distance from point of snout to eye); internarial distance about half interorbital distance. Internarial region between moderate to highly concave. Interorbital distance slightly (approx. 1/5) longer than upper eyelid width. Upper eyelid bearing pungent tubercles. Upper eyelid with a thickened and finely granular border. External border of upper eyelid with minute spicules, slightly projecting beyond eye. Lips not flaring. Eyes protuberant to the sides and above dorsal surface of head. Eye diameter slightly longer than distance from anterior border of eye to naris opening. Lower eyelid translucent (opaque in CIEZAH 323). Palpebral membrane dusted with brown, with a well defined dark brown border. Pupil oval. Temporal region descending vertically. Supratympanic crest moderately to well defined, fleshy, not projecting over temporal region, from posterior border of eye to anterior or medial part of parotoid gland, with smooth borders, not covering tympanum. Tympanum large (horizontal length about 2/3 of horizontal length of eye), conspicuous, rounded to oval, bordered by tubercles, with well-defined elevated borders, and without cartilaginous ring. Supratympanic crest prominent, short and thick, not projecting laterally beyond most external border of upper eyelid, extending with a narrow crest descending almost vertically, bordering tympanum anteriorly; supratympanic crest connected anteriorly with a crest that borders upper eyelids and anterior part of eye. Parotoids oval-shaped, well visible from above, slightly swollen, about twice as long as wide, 1.5 to 2 times larger than width of upper eyelid.

Choanae rounded to oval, large (about 2/3 of internarial distance), located near the margins of roof of mouth, covered or not by palatal shelf of maxillary arch, separated by a distance larger than that between nostrils. Tongue oval, narrow (width about 1/3 of length), with parallel margins; tongue entire in its anterior part, almost completely free (more than 2/3 of its posterior part); teeth absent from maxilla, premaxilla and vomers. Males with lateral vocal slits, at about 40 % of distance from base to tip of tongue, and a possible subgular vocal sac (see below).

Cloacal opening located at or close to midlevel of thighs. Cloacal opening small, directed posteroventrally, at about 2/3 of distance from base to top of thigh. Ulnar fold absent. Hand (fig. 2) with outer metacarpal (palmar) tubercle well defined, large, not divided, slightly heart-shaped; inner metacarpal (thenar) tubercle moderately to well visible, small, about 1/4 to 1/2 size of palmar (sometimes inconspicuous), oval. Supernumerary tubercles present, relatively rounded to squared, of small to very small size. Subarticular tubercles double, rounded, small, conspicuous. Fingers without lateral fringes; fingers almost completely free, except for a short and thick membrane between fingers III and IV; hand web formula I 0 - 0 II 0 - 0 III 1 - 1 IV 0 - 0 V; membrane thick, rugose, tuberculate. Tip of fingers rounded. Digital pads narrower than maximum width of fingers. Relative length of fingers I $\geqslant$ II $<$ III $>$ IV.

Foreleg with numerous small tubercles, some pungent. Tarsal fold absent; narrow groove dividing tarsus longitudinally, from base of fingers IV and V to tibio-tarsal joint. Foot (fig. 3) with an inner metatarsal tubercle prominent, flattened, smooth, oval, slightly elongate in dorsal view, subconical in lateral view, 2.5 times larger than outer metatarsal

Source : MNHN, Paris

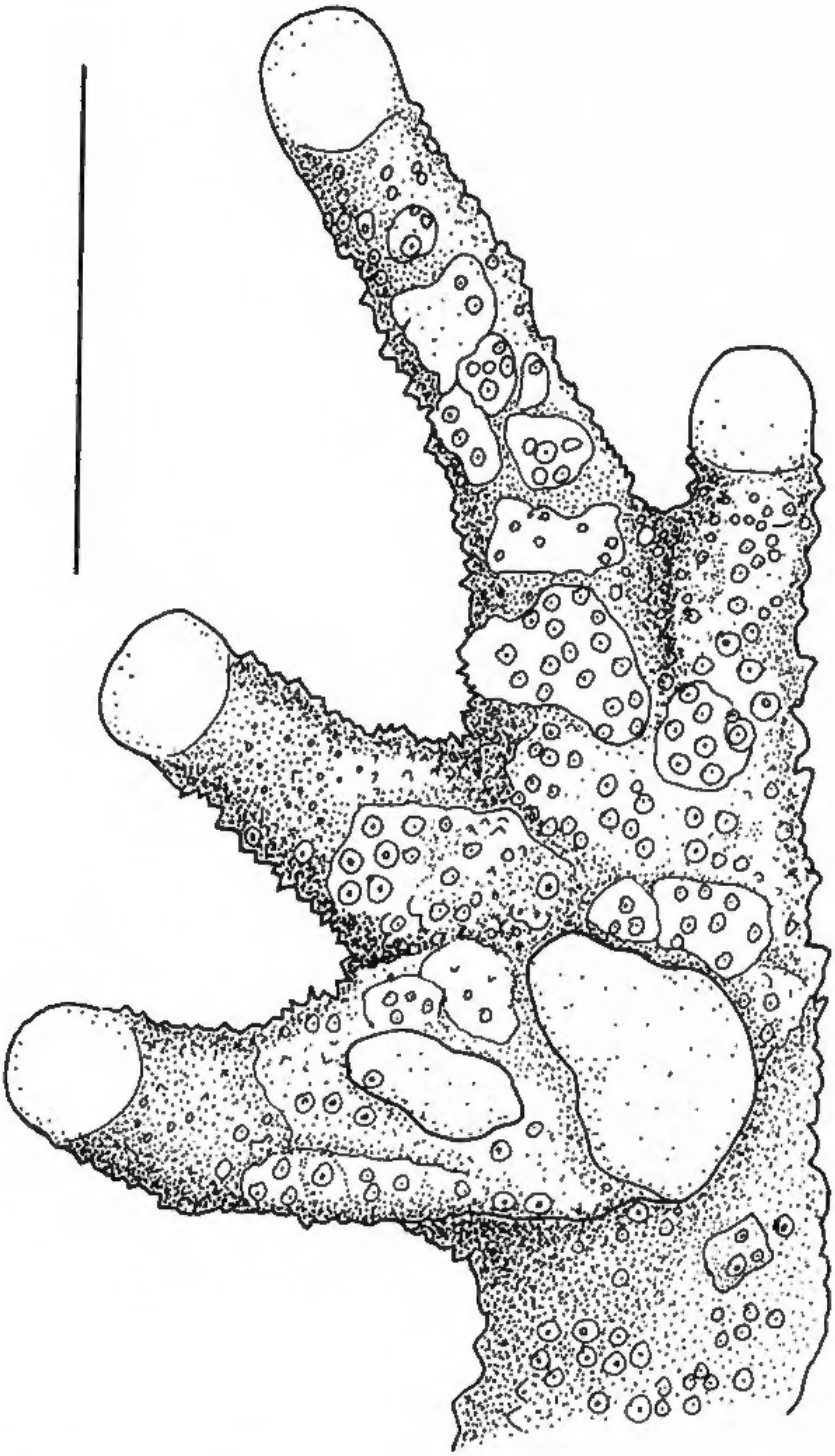

Fig. 2. – Left hand of *Bufo sternosignatus*, ULABG 1319. Note the numerous minute spicules on skin. Line: 5 mm.

Source : MNHN, Paris

Fig. 3. — Right foot of *Bufo sternosignatus*, ULABG 1319. Line: 5 mm.

Source : MNHN, Paris

tubercle, about twice as long as wide. Outer metatarsal tubercle twice as long as wide, smaller than inner metatarsal tubercle, distinct, oval in dorsal view, prominent, flat and smooth. Supernumerary tubercles present, small to medium-sized, with minute spicules. Subarticular tubercles conspicuous, small and oval-shaped. Toe IV with a lateral tuberculate fringe; toe tips rounded; thick tuberculate membrane between toes; maximum web development reaching base of digital pads on left side of toes I, II and III, and right side of V; fourth toe almost completely free; web formula I 1 - 2 II 2 - 2.5 III 2 - 2 IV 1.5 - 1 V; all toes bearing a lateral fringe-like row of tubercles that are a continuation of those on free border of interdigital membrane. Heels not touching or only slightly so when thighs are held at right angles to body axis; tibio-tarsal articulation reaching shoulders when legs are adpressed forward (in the original description, heel is stated to reach eye; in MCNG 2191, heel reaches tympanum; in CIEZAH 318, it reaches between tympanum and shoulder). Relative length of toes: I < II < V < III < IV. Tibia about 37 % body length.

Large cream eggs (up to 1.4 mm diameter) were found in convoluted oviducts of adult females ULABG 1319 and 2406, and (up to 1.9 mm) in CIEZAH 319. Adult males have elongate white testicles (e.g. CIEZAH 317-318), sometimes granulate (e.g. CIEZAH 323); vocal sac is not evident, possibly subgular. Vocal slits may be present on one (e.g. CIEZAH 323) or both sides (e.g. CIEZAH 318). Adult males CIEZAH 317-318 have anterodorsal parts of fingers I and II partially keratinized.

Skin

Skin of dorsum, flanks, throat, venter, extremities (above and below), palms and soles tubercular. Tubercles on dorsum and on top of head between rounded and pungent, from 0.5 to 1.5 mm in diameter, the largest on sides and posterior part of body; a stria longitudinally dividing upper head and body in two equal halves, from snout tip to urostyle or upper border of cloacal opening. Lower back and flank tubercles sometimes ending in one or several (up to 8) spicules. Parotoid glands densely tuberculate. A row of tubercles (sometimes inconspicuous), medium to large-sized, conical shaped, from parotoids to groin; largest tubercles in middle of row. Loreal region with tubercles bearing numerous minute spicules. Upper eyelid with numerous subconical tubercles; those on external border ending in spicules. Temporal region and area near rictus covered by numerous round tubercles, small to moderate-sized. Tympanum densely granular, granules rounded, minute. Tubercles rounded and long (about 1.0 mm long) between upper part of tympanum and supratympanic crest. Neck, in lateral view, with numerous, relatively medium-sized, tubercles in its superior part; scarce and small in its inferior part. Flanks with rounded tubercles, moderate-sized, some pungent.

Venter and throat with small (about 1.0 mm) tubercles, ending in numerous minute spicules; cloacal opening smooth or bordered by rounded tubercles bearing numerous spicules. Tubercles on extremities elevated, subconical, smaller than those on dorsum, generally ending in a single spicule; lower aspect of forearm usually with large subconical tubercles, arranged in two or three longitudinal rows; a longitudinal groove, slightly oblique, from wrist to elbow; fingers totally spiculate, except on distal end, which is smooth; interdigital membranes tuberculate; supernumerary and subarticular hand

Source : MNHN, Paris

tubercles bearing numerous minute pungent spicules. Innner metacarpal tubercle smooth or occasionally with minute spicules. Free margin of hand-web with some minute acute tubercles. Subarticular tubercles on feet with numerous minute spicules.

Measurements in mm (mean ± one standard deviation)

Snout-to-vent length: adult males, 49.5 ± 3.3 (N = 5, range 45.7-55.1); females, 42.3 ± 3.4 (N = 5, range 37.1-47.6). Other measurements (N – 14, both sexes together): head width, 15.1 ± 2.0; head length, 12.4 ± 1.5; eye, 4.5 ± 0.6; eye to tip of snout distance, 5.5 ± 0.6; eye to nostril distance, 3.8 ± 0.6; internarial distance, 2.9 ± 0.4, interorbital distance, 5.2 ± 0.8; eye to tympanum distance, 1.4 ± 0.4; horizontal length of tympanum, 2.6 ± 0.4; hand length, 9.9 ± 1.3; foot length, 14.8 ± 2.1; tibia length, 15.9 ± 2.2.

Coloration

Patterns of dorsal and ventral coloration for the species have been illustrated by Günther (1859: plate 5, fig C) and Lutz (1927*a*. plate 8, figs. 3-4). Rivero (1961: 28) noted that this frog is usually of a reddish colour when alive, and that some specimens are peculiarly marked with yellow and brown below. Data on coloration in life is available for ULABG 1924 (fig. 1) and 3726-3727. Dorsum pale brown bearing a large irregular dark brown to black marking bordered with a pale yellowish line; a cream line from point of snout to end of urostyle; inferior part of flanks dark brown; forearms and thighs with chocolate bands; throat and chest cream; a dirty-cream cross-shaped marking on dark gray chest; upper part of flanks pale brown; lower parts of flanks chocolate. Tympanum marbled with chocolate and dark brown. Numerous cream tubercles, on a plumbeus background, on venter and under the thighs, and two irregular white spots on rear end of upper lip, connected to a white blotch below eye (ULABG 1924). Golden iris, marbled with brown in inferior half, parotoid glands ochre to pale brown, upper lip cream, inconspicuously barred, and groin ochre with a pinkish hue (ULABG 3726-3727). Colour slides of ULABG 1319 (fig. 4) show lower dorsum and cephalic irregular black spots, and a butterfly-shaped dark brown to black marking between eyelids, all bordered with yellow lines. Digits, proximal end of ventral surface of the thighs and axillary surfaces ochre-reddish. Vertebral line, cross on ventral surfaces, lower venter, most parts of ventral parts of thighs and shanks dirty white. Two white spots present at the rear end of upper mandible.

Coloration of preserved specimens is detailed as follows. Dorsum from pale to dark brown, usually with a pale vertebral line, sometimes bordered by black, from point of snout to urostyle, sometimes hidden by a pale brown marking between the eyes. Some specimens bearing dark-brown, bilaterally symmetrical or almost symmetrical markings, on a pale brown background, these markings having sometimes a blackened border (e.g ULABG 1924); some specimens with dark-brown rounded markings, bordered by a pale cream line at level of sacrum (e.g. CIEZAH 317, CVULA 1319). Some specimens (e.g. CIEZAH 318) with pale brown tubercles surrounded by black, and some (e.g. CIEZAH 319 and 322, CVULA 5119, MCNG 2190-2191, ULABG 2940) with a dorsal pale brown subtriangular marking, surrounded by black, with apex directed backwards. All specimens

Source : MNHN, Paris

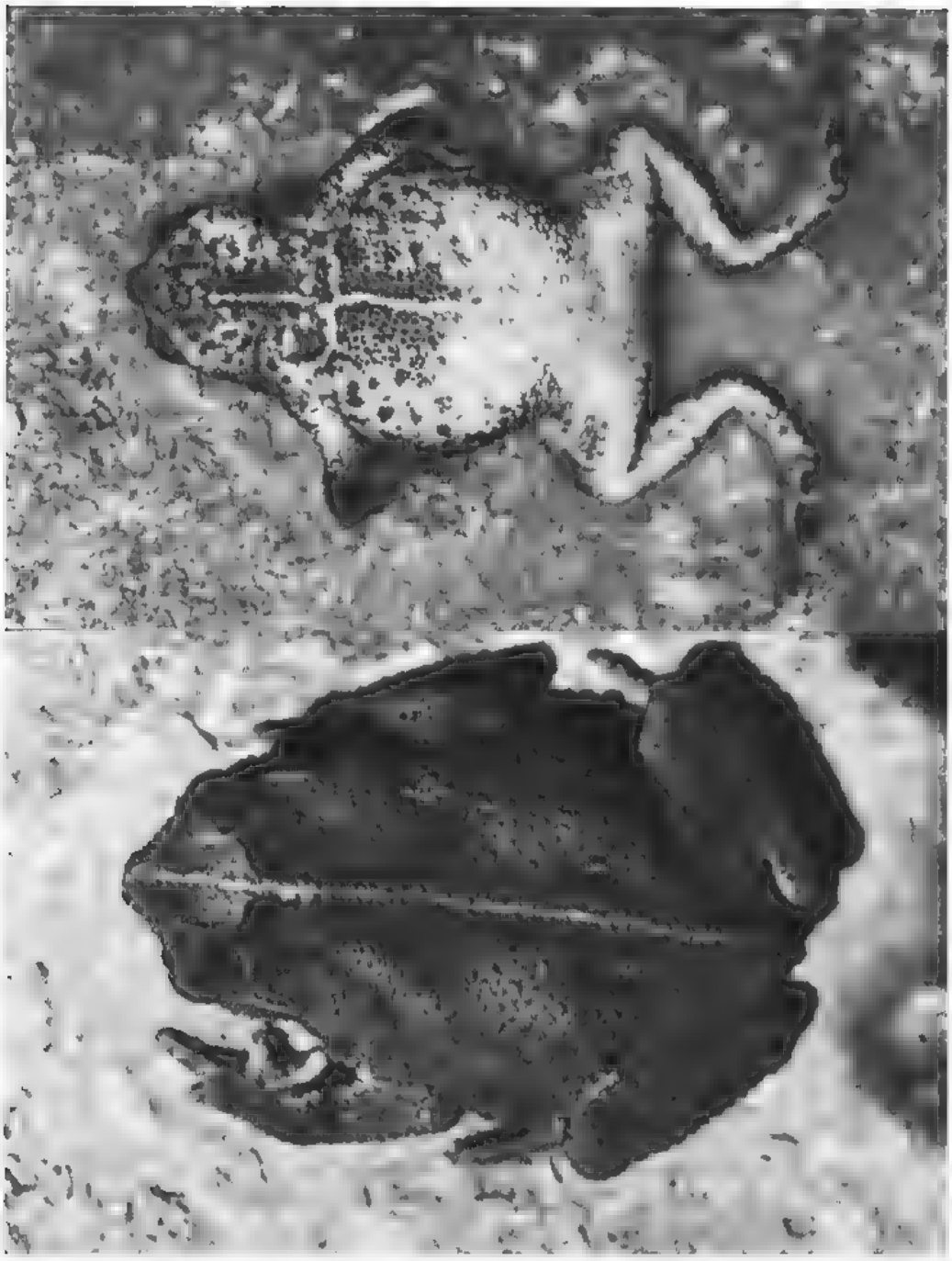

Fig. 4. – *Bufo sternosignatus*, ULABG 1319, adult female, SVL 55 1 mm Bottom dorsal view (note pale vertebral line and dark dorsal markings) Top· ventral view (note pale cross on chest).

Source : MNHN, Paris

examined with dark brown symmetrical markings between the supratympanic crests and the posterior part of the upper eyelids, that may have had a dark (e.g. ULABG 1924) or pale brown (e.g. ULABG 1319) border Two infraocular dark brown bands present, separated by a paler band (sometimes cream-coloured, like CVULA 5119), although one of these bands (or both) may be inconspicuous (e.g. CIEZAH 322). Palpebral membrane dusted with brown, with a well defined dark brown border.

Upper part of flanks same as dorsum; lower part paler, similar to coloration of venter. Extremities, above, generally with dark brown bars on pale brown background; in some instances (e.g. CIEZAH 317-318), the bars are not well-defined. Ventral aspect of hindlimbs immaculate cream. Ventral aspect of forelimbs longitudinally bicoloured (internal half, cream; external half, brown); a dark brown line present from palmar tubercle to almost the elbow. Palms dark-brown, but less than soles, which are the darkest ventral surfaces. Lateral fringe on toe IV made up of tubercles paler than those on top of digit.

Throat and chest usually marbled with brown; border of lower mandible inconspicuously marbled. Anterior part of chest and gular region somewhat darker in CIEZAH 317. Venter usually marbled (most specimens bearing dispersed pale brown specks on a cream background) to completely pale gray (e.g. CIEZAH 318-319). Lower venter, between groin and cloacal region, immaculate cream. A pale-cream cross usually present on chest (conspicuous in CIEZAH 319 and 322 and in CVULA 1319; inconspicuous in CIEZAH 317, ULABG 1924 and CIEZAH 323). The longitudinal line of this pale-cream cross extends from base of throat to middle of the venter; the transversal line connects insertions of arms.

Biogeography

Confusion of *Bufo sternosignatus* with other taxa brought misconceptions about the distribution of the species, that at times has been thought to occur in Central America and Colombia (e.g. Boulenger, 1882), Mexico (Lutz, 1927*a*), and even in "the Guianas, rarely extending farther southwards in eastern Brazil" (Parker, 1935: 528) Central American records probably belong to *Bufo valliceps* and *Bufo typhonius alatus*. Colombian, Guianan and Brazilian records probably correspond to some other forms in the "*typhonius* complex". Venezuelan records in the literature for *Bufo sternosignatus* include mostly specimens from the Cordillera de La Costa: thus, those from Estado Carabobo include Puerto Cabello (Günther, 1859, Boulenger, 1882), Río La Mona and San Esteban ("Río Loma" and "San Esteban trail to Las Cuiguas", respectively, according to UMMZ lists), between Valencia and Caserío Silva ("Palma Sola" in UMMZ lists) and Río Bejuma (Rivero, 1961). From Estado Aragua they include Maracay (Solano, 1969) and Rancho Grande (Rivero, 1961).

Other literature records include: (1) the Distrito Federal: Caracas (Boettger, 1892; Solano, 1969), Mamo, near La Guaira (Lutz, 1927*a-b*, 1955), El Limón, Carayaca and Cerro Avila (Rivero, 1961); (2) the Estado Falcón: Distrito Acosta, Cerro Cosme, Paují (Shreve, 1947; Rivero, 1961); (3) the Estado Portuguesa: La Aparición, between ríos Are

Source : MNHN, Paris

and Guache (RIVERO, 1961, 1964*a*). New records for Estados Barinas, Carabobo, Falcón, Portuguesa, and Trujillo, in Venezuela, are listed above.

Populations of the species from the Falcón region of Venezuela, Cordillera de La Costa and Cordillera de Mérida may currently be isolated from each other by the Yaracuy Depression and some low xerophytic passes. The areas they currently occupy may be the product of a formerly wider distribution during previous warmer interglacial periods of the Quaternary (in which humid forests of all three mountain ranges may have had a more continuous coverage), and its subsequent humid forest breakdown in drier periods (like glacial episodes). Many areas in the Lara-Falcón mountain system are good prospective places where to look for the species. The distribution of *B. sternosignatus* southward reaches Barinitas, in the Los Llanos versant of the Cordillera de Mérida; it may be expected from similar environments down to the Táchira Depression.

Bufo sternosignatus has been reported from elevations of 150 m (ULABG 3947; see above) to 1800 m (precise specimen and locality not stated, in FROST, 1985), in humid premontane forests ("Bosque húmedo premontano" and "Bosque muy húmedo premontano", in the Holdridge's Life Zone System for Venezuela of EWEL et al , 1976). Most of the original vegetation in these environments is lost, specially due to its having been turned into coffee and cacao plantations. The mean annual precipitation of these forests ranges from 1100 to 4000 mm, with water balance favourable during most part of the year, although in the Cordillera de La Costa a short dry period occurs (EWEL et al., 1976). In places with a strong seasonal precipitation (like some forests in the Cordillera de La Costa), populations of *Bufo sternosignatus* may behave as explosive breeders. *Bufo sternosignatus*, like some other species associated with humid premontane forests (e g. *Mannophryne* spp., see LA MARCA, 1992*b*, 1993, 1994*a-b*), is most probably restricted to areas with temperatures between 18 and 24°C. Temperatures away from this range may constitute a physiological hindrance to the species, because more than 24°C increases the evapotranspiration rate and less than 18°C increases the probability of frost (EWEL et al., 1976), thereby resulting in topoclimatic changes that may be adverse to these amphibians. No ecological data have been gathered on the species, and our only data on prey items comes from MCNG 2191 and ULABG 2940, which contained ants and beetles (some Curculionidae).

RESUMEN

En este trabajo proveemos una redescripción de *Bufo sternosignatus*, un sapo pequeño del noroeste de Venezuela generalmente asociado con el "grupo de *B. typhonius*", y datos detallados sobre morfología externa, piel, datos merísticos, patrón de coloración de animales vivos y preservados, y biogeografía

Source : MNHN, Paris

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Acanthocephala parasitic in North American amphibians: a review with new records

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Sixty-nine records of Acanthocephala in North American amphibians are reviewed. In North America, nine adult and two cystacanth Acanthocephala species in six genera have been recorded from 29 amphibian host species. Most reports are from aquatic hosts. Acanthocephala in four of these genera are considered accidental infections. Cystacanths of *Centrorhynchus* species and certain adult *Fessisentis* species are the only regular acanthocephalan parasites of North American amphibians. New host records for *Fessisentis friedi* in *Rana pipiens* and *R. catesbeiana* and *Neoechinorhynchus rutili* in *R. catesbeiana* collected in New Brunswick, Canada, are additional to the previous single report of an adult acanthocephalan parasitic in a North American anuran. In North America, larval Acanthocephala occur in both salamanders and frogs. Adult Acanthocephala in North American amphibians most frequently parasitize aquatic salamanders and only parasitize anurans accidentally. This is in contrast to European amphibians where adult *Acanthocephalus ranae* is common in both salamander and frog helminth communities and acanthocephalan cystacanths have been infrequently recorded as amphibian parasites.

Acanthocephalans are infrequent and relatively uncommon parasites of North American amphibians, although several species, most notably *Acanthocephalus ranae* (Schrank, 1788), are common to such hosts in Europe. In this note, I review the scattered reports of Acanthocephala from amphibians in North America and present new records of Acanthocephala parasitic in bullfrogs, *Rana catesbeiana*, and leopard frogs, *R. pipiens*, collected in New Brunswick, Canada. Acanthocephalan specimens on which new records are based have been deposited in the collections of the New Brunswick Museum.

The earliest report of Acanthocephala parasitic in North American Amphibia is that of Stiles & Hassall (1894), who recorded *Echinorhynchus* sp. from *Notophthalmus viridescens*, the red-spotted newt, collected in Maryland Van Cleave (1915) later identified the seven specimens in this collection as *Acanthocephalus ranae*, a species typical of European amphibians. McAlpine (in press) has re-identified this material as *Acanthocephalus dirus* (Van Cleave, 1931). Holl (1932) commonly encountered an acanthocephalan in the aquatic adult stage of the red-spotted newt which was subsequently described by Van Cleave (1931) as *A acutulus*. McAlpine (in press) demonstrated that these worms belong to the genus *Fessisentis* and should be referred to as

Source : MNHN, Paris

Table I - Records of Acanthocephala from North American Amphibia The use of the terms prevalence, intensity (range), and abundance follow MARGOLIS et al (1982) Where reported sample size for hosts is shown in parenthesis Age class of hosts is noted as larvae (*), larvae and adults (*+) or adults (+)

Species	Age class	Host	Location	Prevalence	Intensity*/ Abundance◆	Source
Acanthocephala sp	cystacanth	*Rana sylvatica* +	Ohio	?	?	ODLAUG (1954)
Acanthocephala sp	cystacanth	*Desmognathus brimleyorum* + (13)	Arkansas	8%	1*	WINTER et al. (1986)
Acanthocephala sp	cystacanth	*Desmognathus brimleyorum* + (41)	Arkansas	2%	1*	MCALLISTER et al (1995a)
Acanthocephala sp	cystacanth	*Desmognathus fuscus* + (16)	North Carolina	31%	1 37◆	MANN (1932)
Acanthocephala sp	cystacanth	*Desmognathus fuscus* + (16)	North Carolina	12 1%	0 53◆	MANN (1932)
Acanthocephala sp	cystacanth	*Desmognathus fuscus* +	North Carolina	3 01%	0 04◆	RANKIN (1937)
Acanthocephala sp	cystacanth	*Desmognathus fuscus* +	North Carolina	3 03%	0 06◆	RANKIN (1937)
Acanthocephala sp	cystacanth	*Desmognathus quadramaculatus* + (46)	North Carolina	0 02%	0 06◆	RANKIN (1937)
Acanthocephala sp	cystacanth	*Plethodon albagula* + (37)	Arkansas	3.0%	1*	MCALLISTER (1993)
Acanthocephala sp	cystacanth	*Plethodon glutinosus* + (20)	North Carolina	5.0%	0.20◆	MANN (1932)
Acanthocephala sp	cystacanth	*Plethodon glutinosus* + (39)	North Carolina	2 5%	0 10◆	MANN (1932)
Acanthocephala sp	adult	*Ambystoma opacum** (18)	North Carolina	31 2%	0 62◆	RANKIN (1937)
Acanthocephala sp	adult	*Desmognathus fuscus**	North Carolina	4 9%	0 09◆	RANKIN (1937)
Acanthocephala sp	adult	*Desmognathus fuscus* +	North Carolina	5 4%	0 07◆	RANKIN (1937)
Acanthocephala sp	adult	*Desmognathus fuscus* + (442)	Illinois	1 1%	0 01◆	DYER et al (1980)
Acanthocephala sp	adult	*Eurycea multiplicata* +	Arkansas	7 1%	2*	FOGLE (1960)
Acanthocephala sp.	adult	*Notophthalmus viridescens* +	North Carolina	3 7%	0 11◆	RANKIN (1937)
Acanthocephala sp.	adult	*Plethodon glutinosus* +	North Carolina	3 4%	0 06◆	RANKIN (1937)
Acanthocephala sp	adult	*Plethodon jordani* + (195)	North Carolina	1 2%	1*	DYER (1983)
Acanthocephala sp	adult	*Siren intermedia* + (2)	Missouri	50 0%	5	DYER & RANDON (1973)
Acanthocephalus sp.	adult	*Ambystoma talpoideum* + (2)	Illinois	50 0%	8*	LANDEWE (1963)
Acanthocephalus sp	adult	*Amphiuma tridactylum* + (85)	Louisiana	1 2%	1*	BENNETT & HUMES (1938), WALTON 1942
Acanthocephalus sp.	adult	*Plethodon glutinosus* + (67)	Louisiana	1 5%	1*	NICKOL (1967, 1969)
Acanthocephalus dirus	adult	*Notophthalmus viridescens* +	Maryland	?	?	VAN CLEAVE (1915), STILES & HASSALL (1984)
Acanthocephalus dirus	adult	*Necturus maculosus* +	Wisconsin	42 9%	6*	AMIN (1985)
Acanthocephalus dirus	adult	*Necturus maculosus* +	Wisconsin	100 0%	1*	AMIN (1985)
Fessisentis acutulus	adult	*Notophthalmus viridescens* + (123)	North Carolina	86 8%	0 64◆	VAN CLEAVE (1931), HOLL (1932)
Fessisentis fessus	adult	*Ambystoma talpoideum* +	Illinois	70%	?	BUCKNER & NICKOL (1979)
Fessisentis fessus	adult	*Siren intermedia* + (3)	Illinois	100 0%	5* (3-10)	LANDEWE (1963), DUNAGAN & MILLER (1973)
Fessisentis fessus	adult	*Siren intermedia* + (68)	Illinois	23 5%	(1-12)	ALTIG (1967), NICKOL (1972)
Fessisentis fessus	adult	*Siren intermedia* +	Louisiana	?	?	NICKOL (1972)
Fessisentis fessus	adult	*Siren intermedia* + (16)	Illinois	81 3%	(2-49)	NICKOL (1972)
Fessisentis fessus	adult	*Siren intermedia* + (24)	Illinois	100%	?	DUNAGAN & MILLER (1973)

Source MNHN, Paris

Table I. (continued)

Species	Age class	Host	Location	Prevalence	Intensity*/ abundance◆	Source
Fessisentis friedi	adult	*Rana catesbeiana* + (12)	New Brunswick	8.3%	2*	This report
Fessisentis friedi	adult	*Rana pipiens* + (101)	New Brunswick	3.0%	1*	This report
Fessisentis friedi	adult	*Rana pipiens* (100)	New Brunswick	1.0%	1*	This report
Fessisentis friedi	adult	*Necturus maculosus* +	Ohio	?	?	BUCKNER & NICKOL (1979)
Fessisentis necturorum	adult	*Ambystoma opacum**	Georgia	86.8%	3.9* (1-22)	NICKOL & HEARD (1973)
Fessisentis necturorum	adult	*Eurycea bislineata / longicauda**	Georgia	37.5%	1.3* (1-2)	NICKOL & HEARD (1973)
Fessisentis necturorum	adult	*Necturus beyeri* + (11)	Louisiana	90.9%	?	NICKOL (1967, 1969)
Fessisentis necturorum	adult	*Notophthalmus viridescens* + (6)	Georgia	16.7%	1*	NICKOL & HEARD (1973)
Fessisentis necturorum	adult	*Pseudotriton montanus**	Georgia	96.0%	3.4* (1-13)	NICKOL & HEARD (1973)
Fessisentis vancleavi	adult	*Eurycea longicauda* + (14)	Arkansas	?	?	SALTARELLI (1977)
Fessisentis vancleavi	adult	*Eurycea multiplicata* + (19)	Oklahoma	42%	?	MALEWITZ (1956)
Fessisentis vancleavi	adult	*Eurycea multiplicata* + (8)	Arkansas	75%	?	SALTARELLI (1977)
Fessisentis vancleavi	adult	*Eurycea multiplicata** +	Arkansas	?	?	BUCKNER & NICKOL (1978)
Fessisentis vancleavi	adult	*Eurycea multiplicata* + (50)	Arkansas	4%	7.5*	MCALLISTER et al. (1995*b*)
Fessisentis vancleavi	adult	*Eurycea tynerensis* + (73)	Oklahoma	13.7%	1.5* (1-3)	HUGHES & MOORE (1943)
Pomphorhynchus bulbicolli	adult	*Notophthalmus viridescens* + (138)	Massachusetts	0.7%	0.08◆	RANKIN (1945)
Leptorhynchoides thecatus	adult	*Ambystoma tridactylum* + (11)	Tennessee	100%	(6-30)	REIBER (1941)
Leptorhynchoides thecatus	adult	*Ambystoma tridactylum* +	Tennessee	?	?	LINCICOME & VAN CLEAVE (1949)
Leptorhynchoides thecatus	adult	*Necturus maculosus* +	Indiana	?	?	LINCICOME & VAN CLEAVE (1949)
Centrorhynchus sp.	cystacanth	*Bufo fowleri* + (62)	North Carolina	1.6%	0.02◆	BRANDT (1936)
Centrorhynchus sp.	cystacanth	*Pseudacris crucifer* + (60)	North Carolina	1.7%	0.02◆	BRANDT (1936)
Centrorhynchus sp.	cystacanth	*Pseudacris brimleyi* + (55)	North Carolina	7.3%	0.13◆	BRANDT (1936)
Centrorhynchus sp.	cystacanth	*Rana catesbeiana* + (33)	North Carolina	81.8%	13.9◆	BRANDT (1936)
Centrorhynchus sp.	cystacanth	*Rana catesbeiana* + (38)	North Carolina	5.3%	0.13◆	BRANDT (1936)
Centrorhynchus sp.	cystacanth	*Rana catesbeiana* + (30)	Virginia	33.3%	5.2◆	CAMPBELL (1968)
Centrorhynchus sp.	cystacanth	*Rana catesbeiana* + (69)	Texas	2.9%	1*	HOLLIS (1972)
Centrorhynchus sp.	cystacanth	*Rana clamitans* + (29)	Virginia	24.1%	6.4◆	CAMPBELL (1968)
Centrorhynchus sp.	cystacanth	*Rana sphenocephala* + (60)	North Carolina	28.3%	2.6◆	BRANDT (1936)
Centrorhynchus californicus	cystacanth	*Hyla regilla* +	California	4.6%	1*	MILLZNER (1924)
Centrorhynchus conspectus	cystacanth	*Desmognathus fuscus* + (54)	Louisiana	3.7%	2*	NICKOL (1969)
Centrorhynchus conspectus	cystacanth	*Desmognathus monticola* + (125)	North Carolina	1.6%	0.02◆	GOATER et al. (1987)
Centrorhynchus conspectus	cystacanth	*Desmognathus quadramaculatus* + (115)	North Carolina	1.7%	0.02◆	GOATER et al. (1987)
Centrorhynchus conspectus	cystacanth	*Plethodon glutinosus* + (67)	Louisiana	3.0%	2*	NICKOL (1969)
Centrorhynchus wardae	adult	*Rana clamitans* + (29)	Virginia	3.4%	0.03◆	CAMPBELL (1968)
Neoechinorhynchus sp.	adult	*Siren intermedia**	Illinois	?	?	MILLER & DUNAGAN (1971) DUNAGAN & MILLER (1973)
Neoechinorhynchus rutili	adult	*Rana catesbeiana* + (204)	New Brunswick	0.5%	3*	This report

Source MNHN, Paris

Fessisentis acutulus (Van Cleave, 1931), while *Acanthocephalus acutulus* reported by NICKOL (1969) is assigned to *Acanthocephalus* sp. Material identified by RANKIN (1937) and DYER & BRANDON (1973) as *A acutulus* is no longer extant, and the identity of these worms is therefore unknown.

The 69 natural infections reported in Table I include encysted cystacanths (from the mesentery, or rarely muscle) and adult Acanthocephala (from the intestine). Experimental infections of *Macracanthorhynchus ingens* (Linstow, 1879) in *Rana pipiens* and of *Fessisentis fessus* Van Cleave, 1931 in *Ambystoma opacum* and *A. tigrinum* reported by MOORE (1946) and BUCKNER & NICKOL (1979) are not included in Table I. Cystacanths have been identified as *Centrorhynchus* sp., *C. californicus* Millzner, 1924 and *C. conspectus* Van Cleave & Pratt, 1940. *Centrorhynchus californicus* was described by MILLZNER (1924) from the mesentery of *Hyla regilla* but has not been reported since. Unfortunately, the type material appears to no longer exist (personal commmunications from J. R. LICHTENFELS, U.S. National Parasite Collection, J. P. DONAHUE, Natural History Museum of Los Angeles, E KOOLS, California Academy of Sciences and D. B. WAKE, Museum of Vertebrate Zoology, University of California).

The 25 North American amphibian cystacanth records are from both salamanders and anurans (56 % vs. 44 %). More than 75 % of these reports are from aquatic hosts. Although hosts such as *Bufo fowleri* and *Pseudacris* species are principally terrestrial outside the breeding season, amphibian cystacanth hosts are most commonly aquatic species. In Europe, unlike North America, there are few records of cystacanths parasitizing amphibians (SCHMIDT, 1985). Several extensive surveys of helminths in European amphibians have not revealed cystacanths parasitizing such hosts (HRISTOVSKI & LEES, 1973; PROKOPIC & KRIVANEC, 1975).

Nine species of adult Acanthocephala in six genera have been recorded as parasites in the intestines of North American amphibians. Records for *Pomphorhynchus bulbocolli* Linkins in Van Cleave, 1919, *Leptorhynchoides thecatus* (Linton, 1891), *Centrorhynchus wardae* Holloway, 1958 and *Neoechinorhynchus rutili* (Müller, 1780) are accidental infections in amphibians since these Acanthocephala are normally parasitic in fish or birds. Prevalences of these species in amphibians were mostly under 1 % and reports were often based on single or few worms. In addition, reports of *C. wardae* in *R. clamitans*, *L. thecatus* in *Amphiuma tridactylum* and *N. rutili* in *R. catesbeiana* are based on worms which were not sexually mature. *Acanthocephalus dirus* infections in *Necturus maculosus* appear peripheral to the usual infections in numerous piscine hosts. Although prevalences of infection were high, host sample sizes for these reports are too small on which to base any conclusions.

CAMPBELL (1968) provided the only previous North American report of an adult acanthocephalan in an anuran, *Centrorhynchus wardae* in *Rana clamitans*. RICHARDSON (1993) noted the strong resemblance between *C. wardae* and *C. conspectus* The host records for *F. friedi* in *R. catesbeiana* and *R. pipiens* presented here are the first reports of *Fessisentis* sp. parasitizing Anura. Among amphibians, aquatic salamanders are the most frequent hosts for *Fessisentis* species (NICKOL, 1969, 1972; NICKOL & HEARD, 1973; BUCKNER & NICKOL, 1979). In nine of 18 infections of amphibians with *Fessisentis* species, where information on prevalences is provided, rates are 70 % or greater, and *Fessisentis*

Source MNHN, Paris

vancleavi and *F. necturorum* are only known as parasites of salamanders (AMIN, 1980). Nonetheless, species of *Fessisentis* have not been encountered as widely in North American amphibians as has been *A. ranae* in European amphibians.

More than 80 % of North American adult acanthocephalan infections have been reported in salamanders from aquatic habitats. Similarly, PEARSE (1932) found Acanthocephala in Japan restricted to salamanders from aquatic environments, suggesting this was because of a dependence on aquatic intermediate hosts. NICKOL & HEARD (1973) reported that *F. necturorum* parasitized only aquatic stages of salamander hosts. Adult Acanthocephala appear rarely to infect North American anurans or any terrestrial or semi-terrestrial amphibian. The accidental infection in *R. clamitans* reported by CAMPBELL (1968), and the Acanthocephala records for *R. catesbeiana* and *R. pipiens* reported here, are the only cases of adult Acanthocephala parasitic in North American frogs. In contrast, *A. ranae* has been regularly reported from both European frogs and salamanders (LEES, 1962; PROKOPIC & KRIVANEC, 1975; KUC & SULGOSTOWSKA 1988*a*), sometimes at prevalences of over 80 % (KUC & SULGOSTOWSKA 1988*b*). WALTON (1942) noted that *N. rutili* has been reported parasitic in *R. esculenta* from Europe.

Although AHO (1990) noted that few parasite surveys of amphibians have been comprehensive, it appears that helminth communities of both European salamanders and frogs regularly include adult Acanthocephala, whereas North American amphibian helminth communities do so infrequently.

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Helminths of the oak toad (*Bufo quercicus*, Bufonidae) from Florida (U.S.A.)

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The gastrointestinal tracts, lungs and urinary bladders of 35 *Bufo quercicus* from Florida (U.S.A.) were examined for helminths. Four genera of nematodes (*Ascarops*, *Cosmocercoides*, Filariidae gen. indet. and *Physaloptera*) and one genus of acanthocephalan (*Polymorphus*) were found. The highest prevalence was 11 % for *Cosmocercoides*, and the greatest mean intensity was 4.5 for *Ascarops* sp. *Bufo quercicus* is a new host record for each of these genera of helminths.

The oak toad, *Bufo quercicus* Holbrook, 1840, occurs in pine woods of the southern coastal plain from southeast Virginia throughout Florida to eastern Louisiana (CONANT & COLLINS, 1991). It is the smallest bufonid in the United States, reaching a maximum size of only 38 mm (ASHTON & ASHTON, 1988). To our knowledge, there are only two reports of helminths in oak toads (WALTON, 1938; HAMILTON, 1955). With worldwide attention focussed on declining amphibians (HEYER et al., 1994), knowledge of the occurrences of helminths and their possible negative impact on anurans has become a topic of interest. The purpose of this paper is to report the occurrences of helminths in a Florida population of *Bufo quercicus* as part of an ongoing study of the biogeography of North American bufonid helminths.

Thirty five *Bufo quercicus* from Florida, U.S.A. (30 males, 5 females, mean snout-vent length SVL = 27.9 mm ± 2.8 SD, range 24-35 mm) were borrowed from the herpetology collection of the University of Florida, Gainesville: UF 9602.1-19, collected April, 1957, Palm Beach County; UF 66801-66810, collected July 1970, Leon County; UF 100225-100230, collected May-June 1977 or 1978, Marion County.

The toads were dissected in situ, i e. without removing organs from the body. The body cavity was opened by a longitudinal incision from throat to vent. The lungs, esophagus, stomach, small intestine, large intestine and bladder were examined under a dissecting microscope. All helminths were removed and identified using a standard glycerol wet mount procedure. Terminology is in accordance with MARGOLIS et al. (1982).

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Ten (29 %) of the 35 *Bufo quercicus* harbored helminths. Nematodes included five adult females of *Cosmocercoides* sp., three third-stage larvae of *Physaloptera* sp., nine encapsulated larvae of *Ascarops* sp., two third-stage larvae of Filariidae gen. indet. and two acanthocephalan cystacanths, *Polymorphus* sp. Helminths were found in the stomach, large intestine and coelom; none were found in the lungs, esophagus, small intestine or bladder. Voucher specimens were deposited in the United States National Parasite Collection, Beltsville, Maryland 20705, U.S.A.: *Ascarops* sp. (85877-85878); *Cosmocercoides* sp. (85879-85881, 85886); *Physaloptera* sp. (85876, 85882, 85885); Filariidae (85884); *Polymorphus* sp. (85883, 85887).

One female and two male toads from Leon County and one female from Marion County harbored five adult females of the genus *Cosmocercoides* (prevalence: 11 %). This represents the highest prevalence found for a helminth in our study. These nematodes were found in the large intestines. Since male nematodes were absent from the collection, it was not possible to determine the species. *Cosmocercoides dukae* has previously been reported from *Bufo quercicus* (WALTON, 1938); however, the collection locality was not stated. *Cosmocercoides variabilis* (previously known as *Oxysomatium variabilis*) was found in *B. quercicus* from Florida and/or Georgia (HAMILTON, 1955). Only two species of *Cosmocercoides* have been reported from North America, namely *C. dukae* and *C. variabilis* (BAKER, 1987) These two species have caused some taxonomic problems in that *C. variabilis* was at one time considered to be a synonym of *C. dukae*. However, VANDERBURGH & ANDERSON (1987*a-b*) showed that such synonymy was incorrect and reported *C. variabilis* to be a normal parasite of the Bufonidae, while *C. dukae* is normally a parasite of molluscs but may occur accidentally in frogs and salamanders which feed on molluscs (VANDERBURGH & ANDERSON, 1987*c*). Thus, the specimens recorded by WALTON (1938) should be referred to *C. variabilis*.

One female and one male toads from Marion County and one female from Palm Beach County harbored three third-stage larvae of *Physaloptera* sp. (prevalence: 9 %). Two larvae were found in stomachs, one was found in the large intestine. Larval physalopterans have been found in several species of *Bufo*, namely, *B. alvarius*, *B. americanus*, *B. cognatus*, *B. debilis*, *B. microscaphus*, *B. retiformis*, *B. speciosus* (as *B. compactilis*) and *B. woodhousii* (KUNTZ, 1940; PARRY & GRUNDMANN, 1965; ASHTON & RABALAIS, 1978; GOLDBERG & BURSEY, 1991; GOLDBERG et al., 1995, 1996), but, apparently, no cases of parasitism of toads by adult physalopterans have been reported. The presence of larvae and lack of adult physalopterans has been reported in many other species of amphibians and reptiles (see GOLDBERG et al., 1993). Species of *Physaloptera* require an insect intermediate host (ANDERSON, 1992); thus, the presence of their larvae in insectivorous species is not unexpected. Because physalopterines are usually found attached to the gastric mucosa (ANDERSON, 1992), our finding one larva in the large intestine suggests that toads are not appropriate hosts for this species and development to maturity does not occur in them.

Two male toads from Palm Beach County (prevalence: 6 %) harbored nine encapsulated larvae of *Ascarops* sp. for a mean intensity of 4.5, highest found in our study. The cysts occurred in the stomach wall, two in one toad and seven in the other. Encapsulated larvae of *Ascarops* sp. have been found in lizards (GOLDBERG & BURSEY,

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1988, 1989; McAllister et al., 1993), birds (Krahwinkel & McCue, 1967) and mammals (Alicata & McIntosh, 1933; Chandler, 1946), but this is apparently the first record of this genus in toads. Two hosts are required for development: adults are found in the stomach of swine, rats and mice, in the esophagus of ruminants and in the crop of chickens (Olsen, 1974); larvae develop in Coleoptera and Odonata (Alicata, 1935). *Ascarops* sp. larvae can be expected in animals that habitually feed upon insects.

One female toad from Marion County (prevalence: 3 %) harbored two filarial larvae in the coelom. Since the reproductive system had not begun to develop, no attempt was made to identify the specimens. Apparently no adult filariids have been reported from North American toads; but, species of *Foleyellides* do parasitize *Rana utricularia sphenocephala* in Florida (Baker, 1987). Whether filariids actually parasitize North American toads or those found in this study represent an accidental infection is not presently known. Further work will be required to answer this question.

One female and one male toads from Marion County (prevalence: 6 %) harbored two acanthocephalan cystacanths. They were in the coelom but attached to the stomach wall. These cystacanths were orange in color, about 0.5 mm in length, and appeared to lack genital spines. For these reasons the cystacanths were identified as *Polymorphus* sp. Amphipods serve as intermediate hosts and ducks serve as definitive hosts for species of *Polymorphus* (Podesta & Holmes, 1970). To our knowledge, there are no other reports of cystacanths in North American toads.

Walton (1938) found one additional nematode from *Bufo quercicus*, namely *Oswaldocruzia pipiens*. Later, Hamilton (1955) reported *Oswaldocruzia subauricularis* from *Bufo quercicus*. Baker (1977) reviewed the North American species of *Oswaldocruzia* and concluded that a single species, *O. pipiens*, was present in North American toads and frogs. Baker (1987) considered *O. subauricularis* to be a South American species; thus, the Hamilton (1955) record should be referred to as *O. pipiens*.

Currently, *Bufo quercicus* may be listed as definitive host of two species of nematodes, *Cosmocercoides variabilis* and *Oswaldocruzia pipiens*, but may serve as a paratenic or accidental host for several other helminths. Prevalence is apparently low: 29 % in this study, 7 % in the study by Hamilton (1955) Because only small numbers of specimens are available from museums for dissections, our sample was restricted to 35 *Bufo quercicus*. Examination of larger samples from throughout the range of *Bufo quercicus* may yield helminth species not previously found

In addition to *Bufo quercicus*, the Floridian bufonid fauna consists of two native (*Bufo terrestris* and *Bufo woodhousii fowleri*) and one introduced species (*Bufo marinus*) (Ashton & Ashton, 1988). Apparently, there are no reports of helminths in these species in the state. Subsequent helminthological examinations will be required before the helminth fauna of these Floridian toads can be compared.

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Erratum

In page 131 of the article quoted below, an unfortunate mistake has led to publication of a version of figure 7 that does not fit with its legend. This earlier version of the figure showed diagrammatic representations of larval tooth row formulae of only 9 species of the genera *Osteocephalus* and *Phrynohyas*, and did not include detailed explanations for the signs and symbols used in the figure. On the other hand, the accompanying legend was that of the final version of this figure, showing 10 species and including detailed explanations of the notation system used in this figure. This is all the more annoying as this notation system was new, and may become adopted by other colleagues for the schematic representation of tadpoles' mouthparts. Next page, we present the figure in its final version, as it should have appeared in the original paper. In order to allow subsequent readers to trace this erratum, we suggest to quote this paper in the future as follows:

SCHIESARI, L. C., GRILLITSCH, B. & VOGL, C., 1996. – Comparative morphology of phytotelmonous and pond-dwelling larvae of four neotropical treefrog species (Anura, Hylidae, *Osteocephalus oophagus*, *Osteocephalus taurinus*, *Phrynohyas resinifictrix*, *Phrynohyas venulosa*). *Alytes*, **13** (4): 109-139; **14** (3): 127-128.

Alain DUBOIS
Chief Editor of *Alytes*

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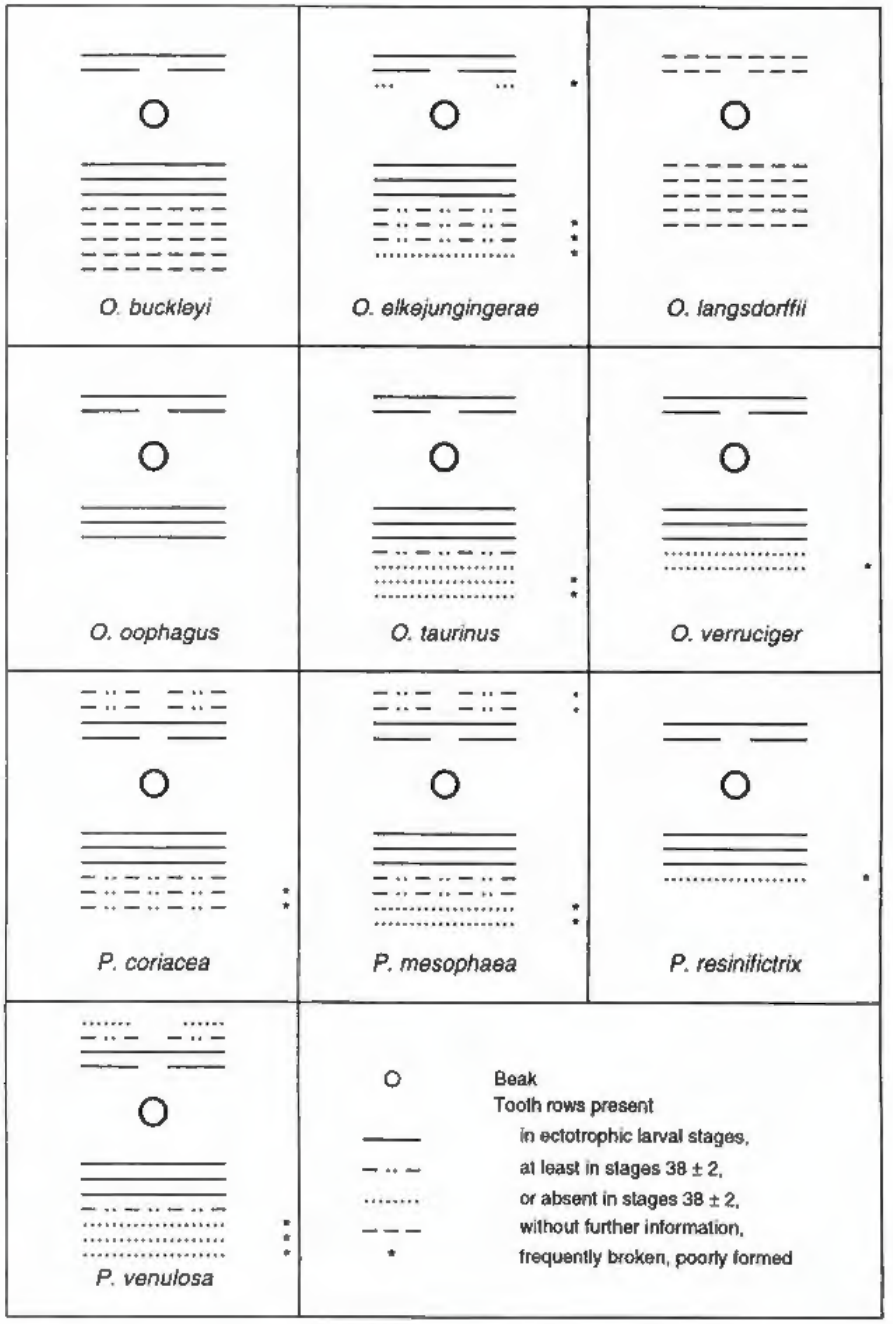

Fig. 7. – Variation of larval tooth row formulae among *Osteocephalus* and *Phrynohyas* species. Schematic drawings; median interruptions and relative lengths of lower tooth rows not considered.

References: *Osteocephalus buckleyi* (HERO, 1990); *Osteocephalus elkejungingerae* (HENLE, 1981); *Osteocephalus langsdorffii* (DUELLMAN, 1974); *Osteocephalus oophagus* (present study and as in Table I); *Osteocephalus taurinus* (present study and as in Table I); *Osteocephalus verruciger* (TRUEB & DUELLMAN, 1970); *Phrynohyas coriacea* (SCHIESARI & MOREIRA, in press); *Phrynohyas mesophaea* (LUTZ, 1973; SCHIESARI, personal observation); *Phrynohyas resinifictrix* (present study and as in Table I); *Phrynohyas venulosa* (present study and as in Table I).

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BOURRET, R., 1942. – *Les Batraciens de l'Indochine*. Hanoï, Institut Océanographique de l'Indochine: i-x + 1-547, pl. I-IV.

GRAF, J.-D. & POLLS PELAZ, M., 1989. – Evolutionary genetics of the *Rana esculenta* complex. *In*: R. M. DAWLEY & J. P. BOGART (eds.), *Evolution and ecology of unisexual vertebrates*, Albany, The New York State Museum: 289-302.

INGER, R. F., VORIS, H. K. & VORIS, H. H., 1974. – Genetic variation and population ecology of some Southeast Asian frogs of the genera *Bufo* and *Rana*. *Biochem. Genet.*, **12**: 121-145.

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Contents

Enrique La Marca & Abraham Mijares-Urrutia
Taxonomy and geographic distribution of a northwestern Venezuelan toad (Anura, Bufonidae, *Bufo sternosignatus*) 101-114

Donald F. McAlpine
Acanthocephala parasitic in North American amphibians: a review with new records 115-121

Stephen R. Goldberg & Charles R. Bursey
Helminths of the oak toad (*Bufo quercicus*, Bufonidae) from Florida (U.S.A.) 122-126

Erratum

Luís C. Schiesari, Britta Grillitsch & Claus Vogl
Comparative morphology of phytotelmonous and pond-dwelling larvae of four neotropical treefrog species (Anura, Hylidae, *Osteocephalus oophagus, Osteocephalus taurinus, Phrynohyas resinifictrix, Phrynohyas venulosa*) 127-128

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